Anaerobic digestion foaming in Danish full-scale biogas plants: a survey on causes and solutions

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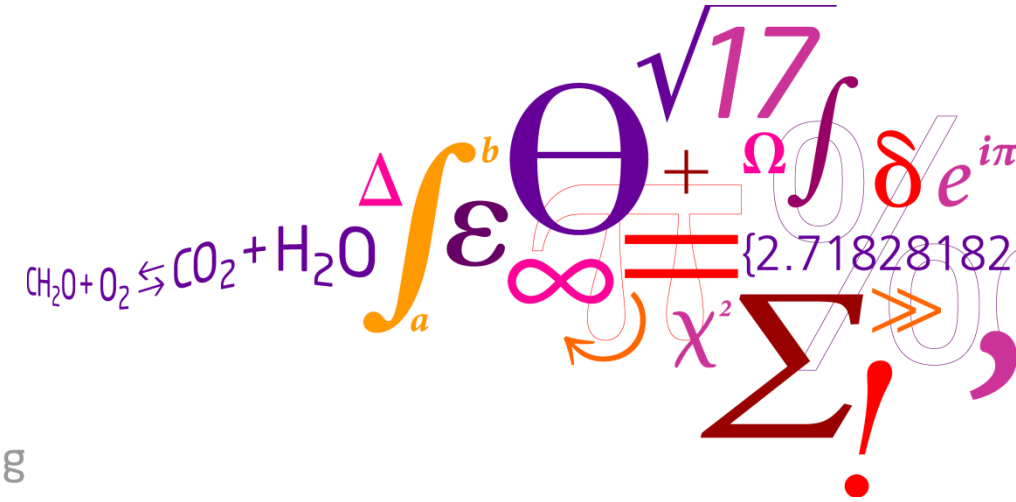


DTU Environment
Department of Environmental Engineering

STATE OF ART

Foam results in:

- **Operational** problems of digesters
- Creation of an **inverse solids profile** in the digesters
- Serious **economic** consequences.
- **Environmental** problems.

STATE OF ART

Parameters that can cause foam in AD:

- Surface active agents
- Organic loading
- Filamentous microorganisms
- Inadequate mixing
- Digester shape
- Temperature

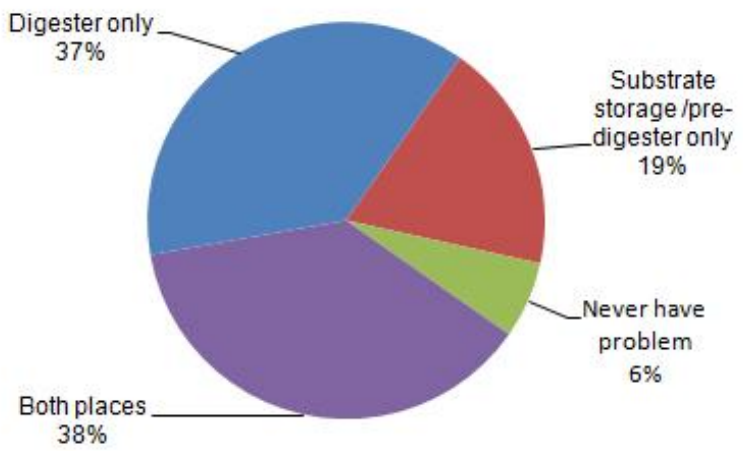
AIM & OBJECTIVES

This work aims:

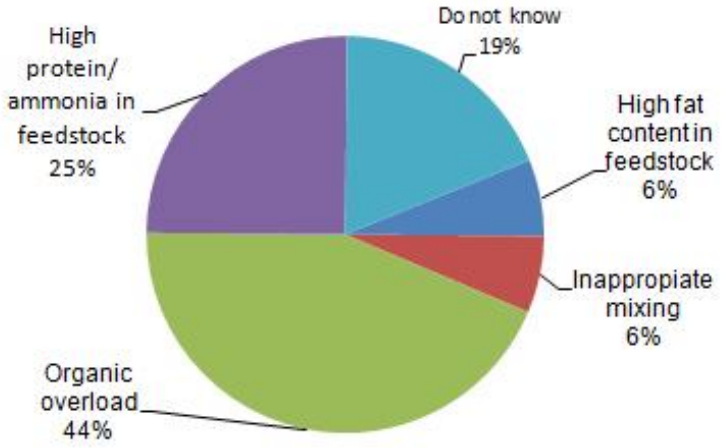
- To identify the **potential causes** of foaming in manure digesters.
- To investigate the **effect of specific compounds** commonly present in a manure digesters on liquid properties and foaming potential in manure.
- To investigate **solutions using antifoam agents.**

SURVEY (16 full-scale biogas plants in Denmark)

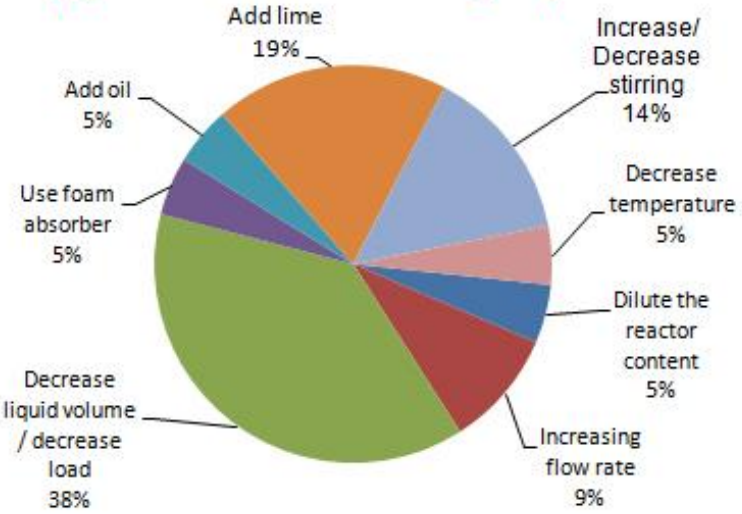
(a) Foaming problem



(b) Causes of foaming



(c) Solutions used in biogas plants

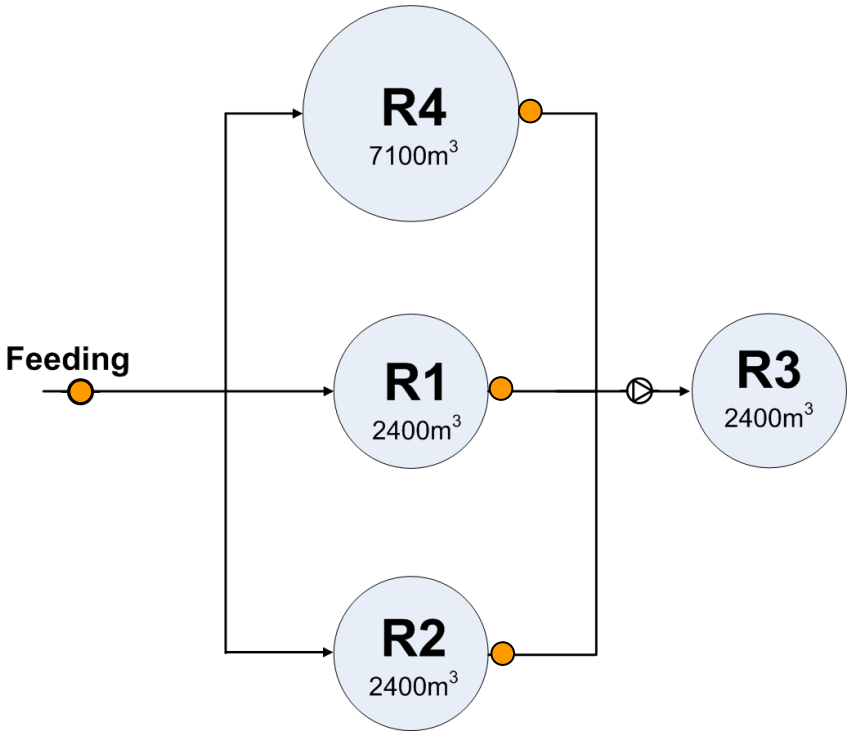


CONCLUSIONS

SURVEY

- Foaming has been recorded in the majority of the full-scale biogas plants in Denmark (**20-50% biogas production loss**)
- **Organic overload** and **the high protein and ammonia concentration** in the feedstock as the most dominant factors for foaming.
- Most common antifoam solution: **Decrease of the organic load or the liquid volume.**

CASE STUDY (Lemvig biogas plant)



- R1, R2, R4 are primary reactors fed with the same substrate.
- R3 is a second stage reactor.
- **Only R4 faced excessive foaming problems (max. 1065 tons foam/day).**

CASE STUDY (Lemvig biogas plant)

Characteristics of feedstock and reactors

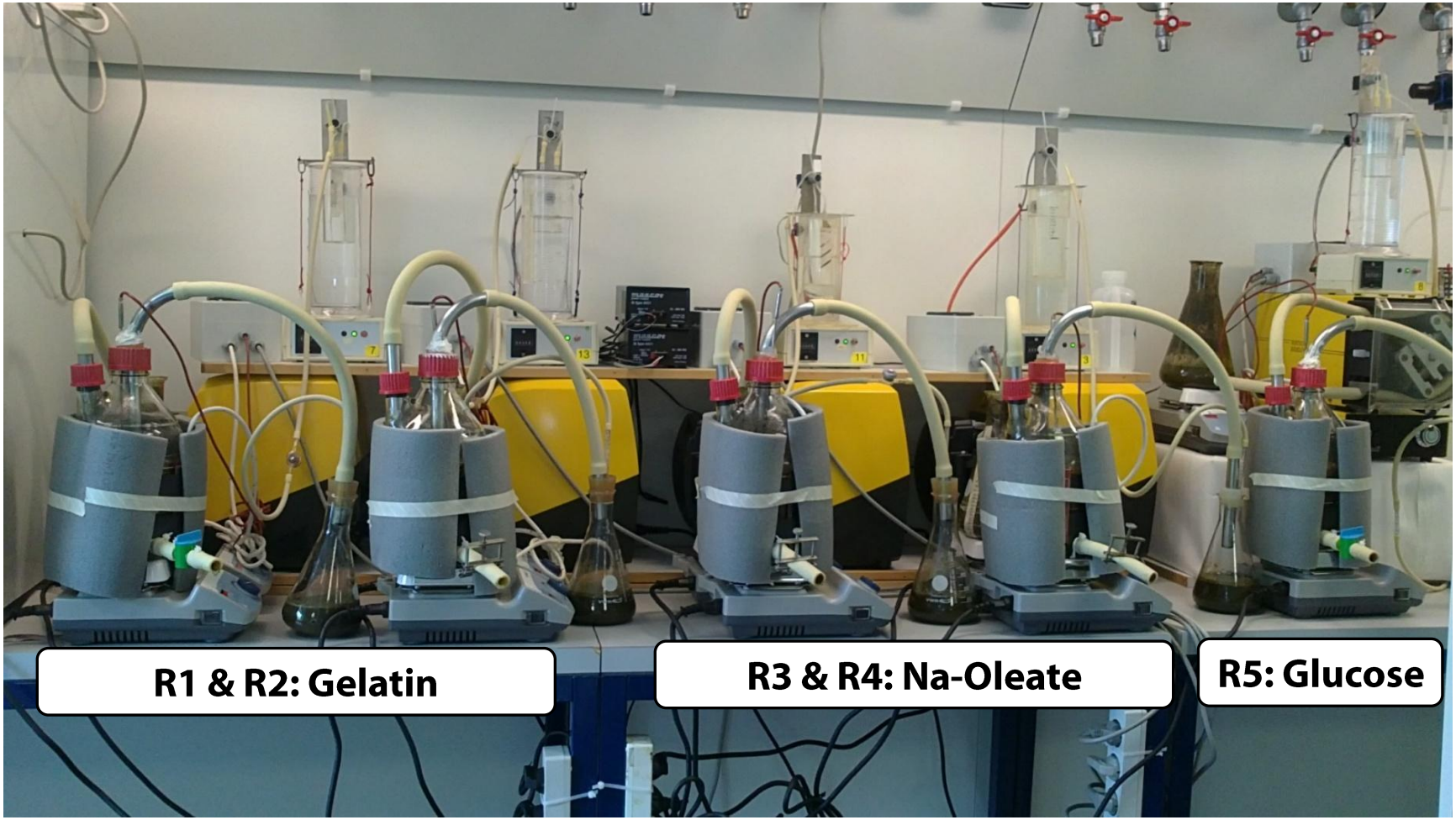
Parameters	R1	R2	R3	R4	Manure	Industrial waste
pH	8.13	8.11	8.15	8.21	6.5	4.3
Alkalinity	5.2	4.5	7.5	**8.1**	6.2	0
Total VFA (g/L)	0.02	0.02	0.09	0.14	8.9	24.6
Biosurfactant activity (mm^2)	5	8.2	7.3	**9.1**	12.5	3.1
Foaming tendency (ml foam/ml-air.min)	25-50	10-90	100-150	**100-200**	50-100	20
Foam stability (ml)	0	0	30	**30**	0	0
Mixing speed (rpm)	200	200	200	**16**	-	-
Reactor size (m^3)	2400	2400	2400	7100	-	-

CONCLUSIONS

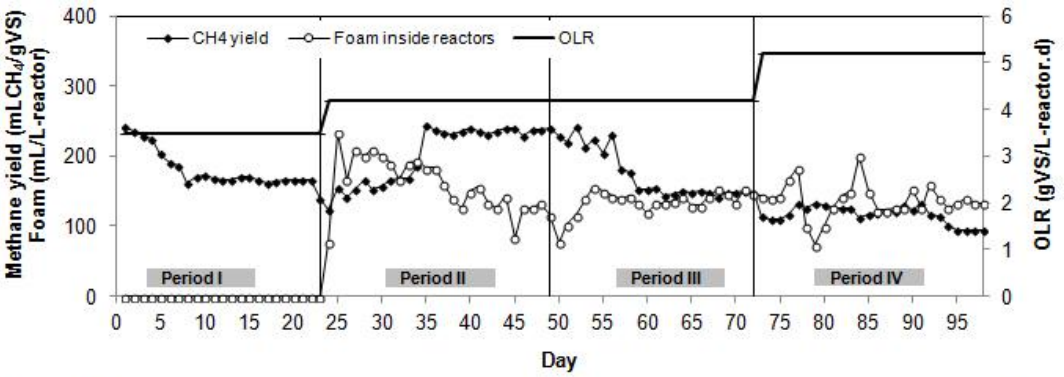
CASE STUDY

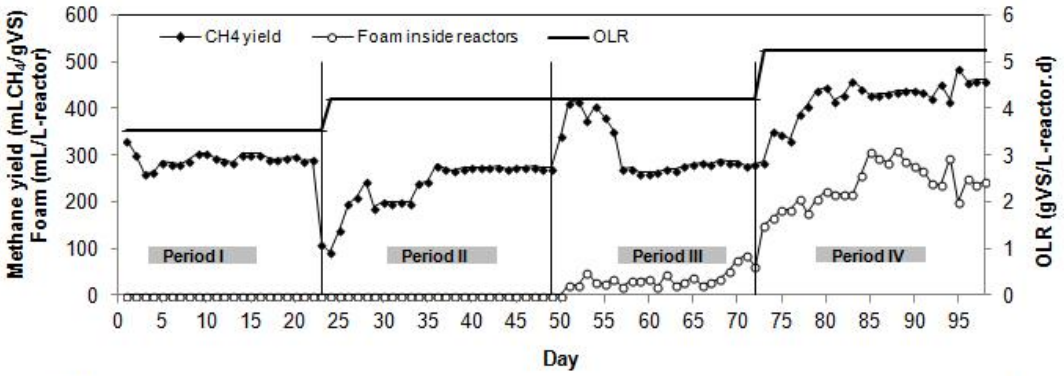
- **Feedstock composition** and the **mixing speed** of the reactor has to be taken into serious consideration in order to avoid foaming incidents.
- Foaming incidents were **not related to** the presence of specific **microorganisms**.

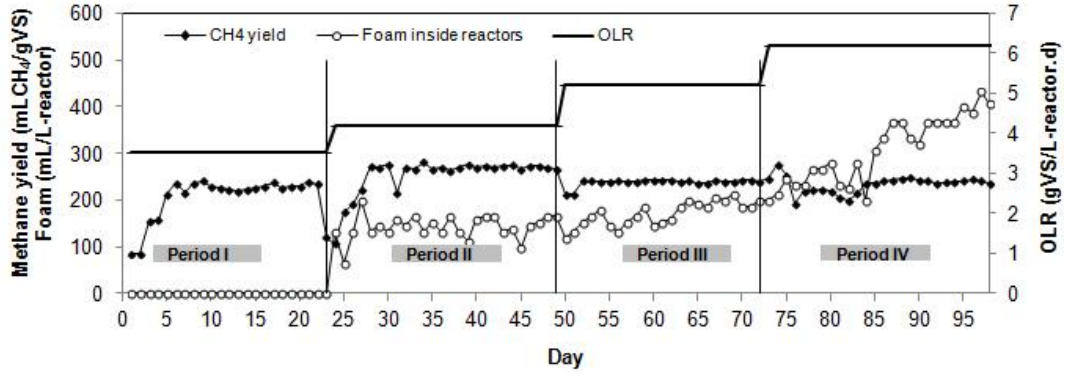
Effect of OLR and feedstock composition



Effect of OLR and feedstock composition







GELATIN

Foam initiation at OLR of 4.2 gVS/L-reactor·d

Na-OLEATE

At OLR 4.2 gVS/(L-reactor·day), low concentration of Na-Oleate (Period II) showed antifoaming effect.

GLUCOSE

Foam initiation at OLR of 4.2 gVS/L-reactor·d

Decrease in methane yield

CONCLUSIONS

CONTINUOUS MODE EXPERIMENT:

- **Organic load** was the main factor affecting foaming.
- Protein initiated foaming at **lower OLR** than lipids.
- Foaming from proteins had **more stable volume** compared to lipids.
- **OLR of 3.5 gVS/(L-reactor·day)** was the critical threshold for foaming.
- **Foaming is rather related to increase of biogas production** and not inhibition.





Thank you!

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